

STUDIES ON ATYIDAE (CRUSTACEA: DECAPODA: CARIDEA) OF SRI LANKA.
V. pH TOLERANCE OF THREE SPECIES OF CARIDINA.

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ABSTRACT

The pH tolerance of Caridina fernandoi, C. pristis and C. simoni was investigated by laboratory experimentation. No significant difference between males and females in their response to different pHs was observed in these species. The ranges of pH tolerance of the three species were found to be 4.7 - 9.0 in C. fernandoi, 5.6 - 9.0 in C. pristis, and 5.2 - 8.5 in C. simoni. Since the pH ranges observed in most water bodies, both standing and flowing, in Sri Lanka fall within these ranges, pH does not appear to be a limiting factor in the distribution of the three species in different parts of the island.

INTRODUCTION

Atyid shrimps are an important component in tropical and subtropical freshwaters, and they occupy in this ecosystem a position comparable to that of isopods and amphipods in the temperate freshwater ecosystem. They are common in the littoral region of both standing and flowing water bodies in the tropics.

However, not much attention has been paid to this group and little is known of the ecology of the group, especially of the factors controlling the geographic distribution of the group in general and individual species in particular.

Ten species of atyids including nine species of Caridina and one species of Atya (A. spinipes) are found in Sri Lanka. Five species of Caridina, namely, C. costai, C. fernandoi, C. pristis, C. singhalensis and C. zeylanica, have so far not been recorded outside Sri Lanka. Different patterns of distribution are observed in different species. C. singhalensis is confined to a single stream at an elevation of 2,100 m, and C. costai has been recorded at an elevation of about 500 m. C. fernandoi and C. simoni are widely distributed from the sea level to about 700 m, while C. pristis is confined to elevations between 450 and 800 m. C. gracilirostris, C. propinqua, C. typus and C. zeylanica show a coastal distribution and are found mainly in the littoral region of lagoons and estuaries. In order to understand the pattern of distribution of a particular species, it is important to study its tolerance to various ecological parameters.

As part of a broader study of the distribution and ecology of Sri Lankan atyids, the present paper examines the pH tolerance of C. fernandoi, C. pristis and C. simoni.

MATERIALS AND METHODS

Samples of each species were collected from three populations. C. fernandoi was collected from Kandy lake, Kurunegala lake and a small reservoir at Ginigathhena; C. pristis was collected from slow flowing streams at Peradeniya University Campus, Galaha and Talatuoya; C. simoni was collected from Sarasavi Oya at Peradeniya University Campus, Kandy lake, and Kospothu Oya at Galagedera. Samples were kept separately in pond water (pH 7.2) in the laboratory at 24°C for at least two weeks prior to experimentation in order to acclimate the shrimps to laboratory conditions. Shrimps were fed with decaying leaves of the bō tree, Ficus religiosa, which were easily obtained and previously found to be readily acceptable to all three species. Under these culture conditions the mortalities were negligible.

Various buffers such as phosphate, citric acid-phosphate, acetate-phosphate, HCl-acetate, glycine-NaCl/NaOH, and HCl-tris were tried at different concentrations but were found to be unsatisfactory because there were high mortalities within a short period even in the pH range in which the shrimps naturally occur. Phosphate buffer was better than the others, but, even in this, most of the shrimps did not survive for more than 15 days. Therefore, pond water with pH adjusted to the required value with either dilute HCl or dilute NaOH was used in the experiments. The pH of the test media was checked every ½-1 hour and adjusted whenever there was a shift of 0.1 or more. Since it was difficult to maintain a constant pH for long periods in this manner with constant manual checking and adjustment, the duration of each experiment was limited to 24 hours, if 100% mortalities did not occur earlier. Such experimental procedures have been used to investigate pH tolerances of other aquatic organisms such as fish (Reite, Maloiy & Assehaug, 1974). Temperature was maintained at 24°C throughout the experimental period.

Each specimen was kept in 100 ml of the test medium in a wide-mouthed 250 ml glass bottle. No food was provided during the short experimental period. Each individual was examined at intervals and the dead animals counted and removed. A shrimp was considered dead when the movement of its scaphognathite had completely stopped and would not resume under gentle probing. Individuals of C. fernandoi and C. simoni in the size range 15-17 mm, and individuals of C. pristis in the size range 12-14 mm were selected for experimentation. These size ranges were chosen to include medium-sized adults.

In order to determine whether there is a difference between males and females in their response to different pHs, ten males and ten females of each species (C. fernandoi and C. simoni from the Kandy lake populations and C. pristis from the Peradeniya population) were selected from the suitable size ranges and were kept at pH 3, 5, 9 and 11. The results (Fig. 1) indicated no significant difference between males and females in their response to different pHs. This observation was useful because the usual method of separating sexes by examination of the second pleopod for the presence of the appendix masculina in the males damages many individuals and therefore is not desirable unless very necessary. No attempt was made, in the subsequent experiments, to separate the sexes, but ovigerous females were excluded.

30 Specimens (10 from each location) of each species were used to test the response to each pH. Experiments were conducted at pH 2, 3, 4, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 10, 11 and 12.

RESULTS

The mean survival rates of individuals from the three population within each species did not differ significantly at any experimental pH in Kruskal-Wallis one way analysis. Therefore, results from all populations were pooled for each species.

Percentage survival times of C. fernandoi, C. pristis and C. simoni at various pHs are given in Figs 2, 3 and 4 respectively. No deaths were recorded within the experimental period of 24 hours between pH 6.0 and 8.5 in C. fernandoi and C. simoni, and between pH 6.5 and 8.0 in C. pristis. The last showed only 90% and 93% survivals at pH 6.0 and 8.5 respectively. 100% mortalities were observed above pH 11 and below pH 3 in all three species within the same period.

The upper and lower ultimate incipient lethal pHs (ILPs) (i.e. the lethal pH levels which on indefinite exposure just fail to kill 50% of the sample) of the three species cannot be determined precisely from the present data, but a rough estimate can be made by plotting the median survival times against pH (Fig. 5). The upper ILPs of C. pristis, C. simoni and C. fernandoi thus calculated appear to be 9.0, 8.5 and 9.0 respectively, while the lower ILPs appear to be 5.6, 5.2 and 4.7 respectively. Thus, it appears that C. fernandoi has better pH tolerance than the other two species, and that C. pristis has the narrowest range of pH tolerance among the three species.

DISCUSSION

pH is an important limnological factor for crustaceans. Too much acidity in water would affect, among other processes, the deposition of calcium salts in the exoskeleton during the hardening process of the latter. However, many crustaceans live in slightly acidic waters and some in distinctly acidic waters.

Atyids are usually found between pH 5.5 and 8.0, but the pH range within which the individual species are found may vary (Table 1).

On the whole, freshwater shrimps and prawns are recorded from more acidic waters in Malaysia than in Sri Lanka (Table 1). This is because most of the freshwaters in southern Malaysia are distinctly acidic (Johnson, 1966). Palaemonids (Macrobrachium spp.) appear to occur in more acidic waters than atyids do in Malaysia (Johnson, 1966). However, in Sri Lanka, both palaemonids and atyids occur in the same pH range except for one atyid species, namely Caridina singhalensis, which occurs at a lower pH of 5.2 at Horton Plains above 2,000 m. Atyids usually occur among the littoral vegetation, the decaying leaves of which may contribute to the acidity of the habitat.

Atyids are widespread in many water bodies below 1,000 m in Sri Lanka. Although there are no natural lakes in Sri Lanka, except for the temporary flood lakes in the Wilpattu and Thamankaduwa regions, creation of many irrigation reservoirs in the dry zone, as well as the large number of streams and rivers present, provide suitable habitats for atyids. From the available data, it appears that the pH of most of these water bodies range from 5.7 to 8.4. Most of the irrigation reservoirs in the lowlands are either neutral or slightly alkaline with a pH range of 6.8 - 7.5, according to Mendis (1965), and 7.6 - 8.4, according to Costa (1980). The flowing water systems appear to be more acidic. For instance, Costa & Starmühlner (1972) recorded pH 5.7 - 8.3 in flowing water systems in the south-west region of the island. The annual range of pH is known only for a few freshwater bodies. For instance, the annual range of pH in Beira Lake is 7.2 - 9.2 (Costa & de Silva, 1978), Kelani river at Hanwella is 5.7 - 8.3 (Costa, 1980), headwaters of Belihuloya at Horton Plains is 5.2 - 6.1 and streams at Peradeniya Campus is 6.3 - 7.8 (K.H.G.M. de Silva & P.K. de Silva, unpublished data). Thus, the range of pH tolerance, taken as the range between the lower and upper incipient lethal pHs, of C. fernandoi (4.7 - 9.0), C. pristis (5.6 - 9.0) and C. simoni (5.2 - 8.5), determined in the present work, are wide enough to allow them to colonize most of the freshwater bodies at all elevations in Sri Lanka. Therefore, the limitations in the range of distribution of the three species, C. fernandoi, and C. simoni from the sea level to 700 m and C. pristis from 450 - 800 m, must be determined by factors other than pH. One of the important factors in this regard appears to be the range of temperature tolerance (K.H.G.M. de Silva, unpublished results).

pH tolerance of Caridina species

Experimental data on pH tolerance of atyids, and even of other freshwater organisms, are scarce. The range of pH tolerance of Caridina singhalensis, which occurs naturally at a pH range of 5.2 - 6.1, is 5.0 - 8.5 (K.H.G.M. de Silva & P.K. de Silva, unpublished data). This range is not much different from those observed in the three species of Caridina studied here. Reite, Maloiy & Aasehaug (1974) experimentally showed that the range of pH tolerance of the cichlid fish, Sarotherodon grahami, is likely to be pH 5 - 11, and that pH lower than 3.5 and higher than 12 caused 100% mortalities in 2-6 hours, the upper range comparable but the lower range less than those of the three Caridina spp. investigated in the present work.

Many other important effects of pH on various aspects of biology of atyids are still to be investigated. For instance, low pH reduced the appetite of the fish Tilapia rendalli (Mabaye, 1971) and also affected its growth (Bardach, Ryther & McLarney, 1972). The effect of pH on the feeding and growth of atyids is not known. Furthermore, pH has been shown to be important for the activity of spermatozoa of fish. Thus spermatozoa of the cichlid fish, Sarotherodon aureus, were only active for a very short period and the eggs failed to fertilize at pH 7.6 - 7.8, whereas at pH 6.5, the spermatozoa were active for a longer period and 80% fertilization occurred (Valenti, 1975). However, pH of the environment may not be so important in the fertilization process of atyids, in which the spermatozoa are directly transferred by the male to the female in a spermatophore.

Presence of metal ions, such as iron, is shown to affect the pH tolerance of fish (Prowse, 1966). Huet (1972) points out that although the lower range of pH tolerance for most fish species is 4.5, this is lowered to 5.5 if high quantities of iron are present. Such situations may occur in the natural habitat. This effect is probably due to iron depositing as hydroxide on the gills where there is likely to be a higher pH due to ammonia excretion. Such effects are not yet investigated in atyids.

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pH tolerance of Caridina species

Table 1

pH range in which some species of atyids and palaemonids naturally occur. (Data on Malaysian shrimps are from Johnson (1966), and those on Sri Lankan species are from Mendis (1965), Costa & Starmühlner (1972), Costa (1979; 1980) and K.H.G.M. de Silva & P.K. de Silva (unpublished).

	Malaysia	Sri Lanka
<u>Caridina fernandoi</u>		5.8-7.8
<u>C. gracilirostris</u>	5.4-7.0	6.3-7.0
<u>C. pristis</u>		5.8-7.8
<u>C. propinqua</u>	5.4-8.2	6.3-7.2
<u>C. simoni peninsularis</u>	5.9-8.2	
<u>C. simoni simoni</u>		5.8-8.3
<u>C. singhalensis</u>		5.2-6.1
<u>C. typus</u>	6.0-7.3	6.3-8.3
<u>C. weberi</u>	5.6-7.5	
<u>C. zeylanica</u>		6.4-7.8
<u>Atya spinipes</u>		6.8-8.3
<u>Macrobrachium</u> spp. (Palaemonidae)	4.4-7.4	6.0-8.0

Legends to figures

- Fig. 1. Survival of males and females of C. fernandoi, C. pristis and C. simoni at pH 3, 5, 9 and 11 (solid symbols-males, open symbols - females)
- Fig. 2. Survival of C. fernandoi at each experimental pH. Percentage survival is plotted on probability scale, and survival time on a log scale.
- Fig. 3. Survival of C. pristis at each experimental pH. Percentage survival is plotted on probability scale, and survival time on a log scale.
- Fig. 4. Survival of C. simoni at each experimental pH. Percentage survival is plotted on probability scale, and survival time on a log scale.
- Fig. 5. Relationship between median survival time (MST) and pH for C. fernandoi, C. pristis and C. simoni. MSTs were calculated from Figs. 2,3 and 4, and plotted on a log scale.









